Soil sampling

APPROPRIATE ANALYSES FOR NEW MEXICO SOILS AND GENERAL INTERPRETATION OF SOIL TEST RESULTS

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Food comes from the earth. The land with its waters gives us nourishment. The earth rewards richly the knowing and diligent, but punishes inexorably the ignorant and slothful. This partnership of land and grower is the rock foundation of our complex social structure.

- W. C. Lowdermilk

Soil testing is an attempt to understand the environment in which plants we are growing must survive. A complete understanding of the soil would include the physical, chemical, and biological properties. Physical characteristics of relevance to plant production include soil texture, permeability, compaction, and water holding capacity. Chemical properties include soil pH, salinity, plant nutrients, reactivity, and ion exchange. The biology of the soil determines how efficient nutrients are released from organic matter or how well organic matter is decomposed as well as how the soil "breathes" or respires carbon dioxide.

OBTAINING A SAMPLE

A soil test is only as good as the sample from which it came. One core from a field such as that in figure 1 would not really represent that field. Samples should be taken from areas that can be treated as a distinct unit. The shallow soils are different from the deeper soil boundaries and vary vastly in in soil physical and chemical properties (Figure 1). It usually takes between 12 and 15 subsamples that are combined into one sample in order to be 90% confident in soil test results that come back from the lab. This many sub-samples assures that you have retrieved soil that is representative of a management zone.

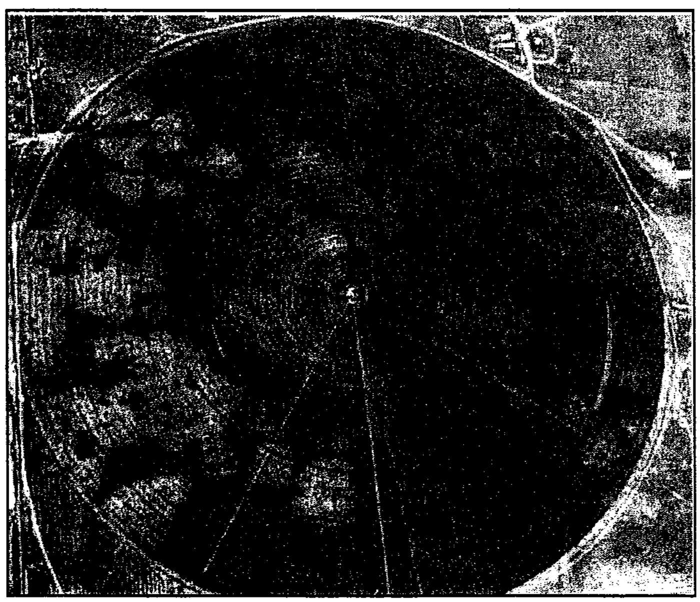

Figure 1. Proper soil sampling is necessary to accurately represent a field.

The soil depth for sampling should be between 6- and 8-inches. The tool of choice is a probe that allows easy retrieval of the soil without leaving

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behind a greatly disturbed area. Some soils are too hard to easily push a probe and a little persuasion is needed with the assistance of a hammer probe.

What to test for

New Mexico State University routinely tests soil for the following properties: pH, electrical conductivity, calcium, magnesium, sodium, organic matter, inorganic nitrogen, phosphorus, potassium and texture. These tests are unique to New Mexico as there are specific ways the soil is handled in the lab to arrive at the numbers. Soil pH, electrical conductivity, calcium, magnesium, and sodium are determined from what is known as a saturated paste. Organic matter is determined from a specific procedure common to many labs known as the Walkley-Black method. Inorganic nitrogen is determined using a procedure that extracts the two forms of inorganic nitrogen, ammonium and nitrate. Phosphorus is determined from extracting the soil with a solution of bicarbonate. This extractant is commonly used on soils with a pH above 7.2 and is better correlated to what a plant can actually remove from the soil environment. Potassium is determined from a water extract rather than ammonium acetate that is used by most other labs. Micronutrients are required by plants in small quantities and can be evaluated through soil testing using an extract known as DTPA (diethylenetriaminepentaacetic acid).

Saturated Paste

The saturated paste is made on a soil sample because the tests that are done with the paste have been correlated to plant response. The procedure usually takes 24 hours to complete and the ending sample is put under high suction and the liquid withdrawn from the paste. The pH, electrical conductivity, calcium, magnesium and sodium are then determined on this water sample. The sample is known as the saturated paste extract and most closely resembles what a plant "sees" under irrigated conditions.

Soil pH

Soil pH is a measure of the acidity or basicity (alkalinity) of a soil. A liquid is said to be acid if the pH is below 7.0 and alkaline if the pH is above 7.0. A neutral soil has a pH of 7.0. Technically, soil pH is the negative logarithm of the hydrogen ion activity ($-\log_{10}(H^+)$) in the soil. Common household items that are acidic include vinegar, coke, and coffee while detergents, bleach, and Tums are alkaline. Rain is naturally acidic with a pH of 5.6.

Ideally, soil pH should be near 6.5 in order to keep phosphorus in its most available form. Many micronutrients such as iron and zinc are also more available to the plant at a 6.5 soil pH. Other nutrients for plant growth are also strongly affected by soil pH. Only nitrogen, potassium, and sulfur are unaffected by soil pH.

Soil pH in New Mexico is normally between 6.5 and 8.4. Mountain soils, where more rain occurs, generally have a soil pH below 7.0. Many garden soils that have received too much organic matter also have a low soil pH. For much of the state, soil pH is controlled by the presence of calcium carbonate (lime). Lime acts as buffer against changes in soil pH. A quick test to see if there is free lime in the soil simply pour a little vinegar on the soil. If the soil fizzes then there is free lime in the soil. A soil with 5% lime in the top 6-inches has approximately 2,296 lb of lime per 1,000 square feet. *All* of this lime must be neutralized before the soil pH can be lowered. Elemental sulfur is a common amendment used to lower soil pH. However, additions of amendments like this do cost money. It is often more economic to establish plants that are tolerant of alkaline soils and are not sensitive to soil lime. This way, additional amendments are not added during the life of the plant to keep the plant green and alive.

If your soil does not have any free lime then the following table can be used to estimate the amount of elemental sulfur needed to lower the soil pH. Notice you also need to know the soil texture in order to apply the correct amount.

Table 1. Pounds of elemental sulfur to lower soil pH with *no* free lime present.

pH Change	Sand	Loam	Clay
		lb sulfur per 1,000 square feet	
8.5 to 6.5	46	57	69
8.0 to 6.5	28	34	46
7.5 to 6.5	11	18	23
7.0 to 6.5	3	4	7

Soil Electrical Conductivity (E.C.)

Electricity can be used to determined how "salty" a solution of water is. Pure water will not conduct electricity but as soon as a little salt is present electricity is conducted through the solution. Salts are not limited to table salt (sodium chloride). Soil salts refer the amount of calcium, magnesium, potassium, bicarbonate, carbonate, chloride, sulfate, nitrate, and sodium that are present. Potassium chloride is a major source of fertilizer potassium (potash) but is also a salt. Too much fertilizer can result in too much salt and crop injury can occur. A conductivity meter is used to give a number that relates to how salty a solution is. Table 2 shows how "salty" some solutions are. Note that these are fertilizers. Fertilizers are salts.

Table 2. Salinity of common fertilizers using 1 Tablespoon/liter of distilled water unless noted otherwise.

Source	conductivity dS/m	Source	conductivity dS/m
Distilled water	0	Ammonium Nitrate	191
Tap water	0.5 - 5	11-52-0	81
Urea (42-0-0)	4	Muriate of potash	210
Ammonium sulfate (21% N)	230	15-30-15 (1 t/gal)	10

Keep in mind, however, that for plant growth, this number does not mean anything until it is "interpreted" or correlated to plant response. In general, a soil is said to be saline if the conductivity of the saturated paste extract is greater than 4 dS/m (or mmhos/cm). Saline soils do not necessarily mean there is the presence of sodium. A saline soil also has a pH less than 8.5 and an exchangeable sodium percentage less than 15%.

Grasses vary in their response to salinity (Table 3). To read the table, find the plant of interest and move to the right. The third column tells us at what point the plant is first affected by soil salts. The higher the number the more tolerant the plant to soil salts. The fourth column is slope and means how much damage or reduced growth can occur for every unit increase in salinity. Barley, for example, has a slope of 5.0 which implies that for a change in salinity from 8.0 to 9.0 there will be 5% drop in yield.

Table 3. Relative Salt Tolerance of selected fiber, grain, & specialty crops.

Common Name	Botanical Name (b)	Threshold dS/m (c)	Slope % per dS/m	Rating (d)	Lime Tolerance	Protein Potential	Fert. Requir.
Alfalfa	*Medicago sativa L.*	2.0	7.3	MS	Low	Med.	High
Alkali sacaton	*Sporobolus airoides (Torr.)*	--	--	T*	High	Med.	Low
Alkaligrass, Nuttalls	*Puccinellia airoides JA Schultes*	--	--	T*	Med.	Low	Low
Barley	*Hordeum vulgare L.*	8.0	5.0	T	High	Low	Med.
Bermudagrass	*Cynodon dactylon (L) Pers.*	6.9	6.4	T	Low	High	Med.
Brome,smooth	*Bromus inermis Leyss.*	--	--	MS	High	High	Med.
Clover, red	*Trifolium pratense L.*	1.5	12.0	MS	Med.	Med.	High
Clover, white	*Trifolium repens L.*	1.5	12.0	MS	Med.	Med.	Med.
Corn	*Zea mays L.*	1.7	12.0	MS	Med.	High	High
Cotton	*Gossypium hirsutum*	7.7	5.2	T	High	Med.	Med.
Cowpea	*Vigna unguiculata*	4.9	12.0	MT	None	High	Med.
Fescue, tall	*Lolium arundinaceum (Schreb)*	3.9	5.3	MT	Med.	Med.	Med.
Grama, blue	*Bouteloua gracilis (Willd. Ex Kunth)*	--	--	MS*	High	Med.	Low
Oats	*Avena sativa L.*	--	--	MT*	Low	Med.	Med.
Orchardgrass	*Dactylis glomerata L.*	1.5	6.2	MS	High	Med.	Med.
Panicum, blue	*Panicum antidotale Retz.*	--	--	MT*	Low	Med.	High
Rhodes grass	*Chloris gayana Kunth.*	--	--	MT	None	Low	Med.
Rye	*Secale cereale L.*	11.4	10.8	T	Med.	Med.	Med.
Ryegrass, perennial	*Lolium perenne L.*	--	--	MS*	Med.	High	Med.
Saltgrass, inland	*Distichlis stricta (L.) Greene*		--	T*	High	Low	Med.
Sorghum	*Sorghum bicolor (L) Moench*	6.8	16.0	MT	Low	Med.	High
Sudangrass	*Sorghum sudanense Piper*	2.8	4.3	MT	Low	High	High
Sunflower	*Helianthus annuus L.*	--	--	MS*	Med.	Low	Med.
Sweetclover, white	*Melilotus alba Medikus*	--	--	MT*	High	High	High
Timothy	*Phleum pratense*	--	--	MS*	High	Med.	Med.
Triticale	*X Triticosecale*	6.1	2.5	T	High	High	High
Vetch, american	*Vicia americana Muhl. Ex Willd.*	--	--	VS	Low	High	High

Common Name	Botanical Name (b)	Threshold dS/m (c)	Slope % per dS/m	Rating (d)	Lime Tolerance	Protein Potential	Fert. Requir.
Wheat	*Triticum aestivum L.*	6.0	7.1	MT	Med.	Med.	High
Wheatgrass, western	*Pascpyrum smithii (Rybd.)*	--	--	T	High	Med.	Med.
Wheatgrass, tall	*Agropyron. elongatum*	7.5	4.2	T	High	Med.	Med.
Wheatgrass, inter.	*Agropyron interMed. (Host.) Beauv.*	--	--	MT*	High	Med.	Med.
Wildrye, Russian	*Leymus junceus (Fisch.)*	--	--	T	High	Med.	Low
Wildrye, Altai	*Leymus angustus (Trin.) Pilger*	--	--	T	Med.	Med.	Low
Wildrye, Canadian	*Leymus. canadensis*	--	--	MT*	High	Med.	Med.
Wildrye, beardless	*Leymus triticoides (Buckl.)*	2.7	6.0	MT	High	Med.	Med.

Notes:

(a) These data serve only a guideline to relative tolerances among crops. Absolute tolerances vary, depending upon climate, soil conditions, and cultural practices.

(b) Botanical and common names follow the convention of Hortus Third (Liberty Hyde Bailey Hortorium Staff, 1976) where possible.

(c) In gypsiferous soils, plants will tolerate ECe about 2 dS/m higher than indicated.

(d) Ratings with a * are estimates.

Management of saline soils includes leaching, selecting salt tolerant plants, and other management practices that are developed from interpreting the soil test. Chemical amendments are not usually needed for strictly saline soils. Amendments become necessary if sodium is excessively high in a soil test.

Specific ion effects - sodium

Calcium, magnesium and sodium are also determined from the saturated soil paste extract. The ratio of sodium to calcium and magnesium determines how likely a soil will be affected by the sodium ion. Two properties of soil are calculated from these three ions and are reported as the Sodium Adsorption Ratio (SAR) and the exchangeable sodium percentage (ESP). The SAR tells us the relative activity of sodium in exchange reactions in the soil while the ESP is the degree of saturation of the soil exchange complex with sodium. Sandy soils are less prone to the effects of sodium than clay soils.

A soil is defined to be sodium affected if the ESP is greater than 15%. A soil does not have to be saline in order to be considered sodium effected. The electrical conductivity of a sodium affected soil is, by definition, less than 4.0 dS/m. Sodium affected soils usually have a pH greater than 8.5. These soils have poor structure because the sodium disperses the soil particles and reduces the large pore space. This makes leaching very difficult since the soil becomes like concrete keeping water on the surface. The amendment most commonly used is gypsum and application rates are based on the concentration of sodium and the ESP of the soil (Table 4).

Table 4. Pounds of pure gypsum per acre needed to reduce the ESP by 5%.

	Exchangeable Sodium Percentage (ESP)						
Sodium	6	7	8	10	12	15	20
ppm¶			pounds gypsum per acre				
300	850	1450	1900	2550	3000	3400	3850
400	1150	1950	2550	3400	3950	4550	5100
500	1400	2450	3200	4250	4950	5650	6400
600	1700	2900	3850	5100	5950	6800	7650
800	2250	3920	5097	6795	7971	9060	10193
1000	2850	4574	6403	8494	9888	11369	12763
1500	4250	7318	9540	12763	14898	16988	19166
2000	5650	9714	12763	16988	19863	22695	25483

¶ NMSU reports sodium in milliequivalents (meq/L) per liter which can be converted to ppm by multiplying by 23 (meq/L x 23 = ppm).

A soil that is both saline and sodium affected proves to be the worst case scenario for management. By definition, these soils have an E.C. above 4.0 dS/m and an ESP greater than 15%. Sometimes this type of soil contains gypsum which can be dissolved with irrigation water to help reclaim the soil by providing more calcium to the soil exchange sites. Otherwise, amendments containing calcium are usually required and there must be good drainage in order for reclamation to work.

Soil Organic Matter

A standard soil test for organic matter should be run on most soils to give an idea of the nutrient reserve that is in the soil, improved water holding capacity over the mineral portion of the soil, and problems that might develop from excessive amounts of organic matter.

Soil organic matter (SOM):

1. Helps strengthen soil aggregates, thus improving soil tilth and structure
2. Improves aeration and water infiltration
3. Increases water holding capacity (0.08" to 0.19" per 1percent SOM)
4. Provides significant amounts of nutrient exchange sites
5. Buffers against rapid changes in soil reaction
6. Forms stable organic compounds that can increase the availability of micro-nutrients
7. Provides a source of plant nutrients (30 lb N/A per year per 1 percent % SOM per foot of soil)
8. Provides a food source for soil microorganisms.

Table 5. Soil organic matter classification.

Sandy Texture	*Clay Texture*	*Classification*
% S.O.M. range		
Less than 0.5	Less than 1.0	Very Low
0.5 - 1.0	1.0 - 2.0	Low
1.0 - 1.5	2.0 - 3.0	Moderate
More than 1.5	More than 3.0	High

Organic matter also tends to lessen the effects of salinity on plant growth. Research at NMSU is on going about the relationship between nutrient rich and sterile organic matter crop response to salinity.

Nutrient Analysis

Three primary nutrients are tested on a routine basis at the NMSU Soil and Water Testing Laboratory in Las Cruces. These nutrients include inorganic nitrogen, phosphorus, and potassium. Four micronutrients can also be requested and include iron, zinc, copper and manganese. The nutrients are ranked according to the likelihood of a response to additional applications of the nutrient in question. There are small modifications that are made for plants that have a "response curve" established for New Mexico conditions.

Nitrogen

Inorganic nitrogen is reported as nitrate. Table 6 categorizes the inorganic nitrogen levels in soil into five broad categories.

Table 6. Interpreting soil inorganic nitrogen levels.

Nitrate-N classification	ppm	Chance of a Response to added N	Nitrate-N classification	ppm	Chance of a Response to added N
Very Low	< 3	High	High	31 - 50	Not likely
Low	3 - 10	High	Very High	>50	Not likely
Medium	11 - 30	Moderate			

The quantity of fertilizer nitrogen to apply is based on the amount of nitrogen in the soil and the amount of nitrogen required to adequately promote growth and performance of a given crop. Fast-growing plants generally require more nitrogen than slow growing plants. Table 7 provides some guidelines for some pasture species that would be appropriate for selected areas in New Mexico. Nitrogen fertilizer applications may be eliminated (at first) if the soil test is rated high for inorganic nitrogen. Applications of fertilizer should be made when temperature and moisture conditions favor active growth. Fertilizers should not be applied during times of stress.

Table 7. Fertilizer nitrogen rates for selected grasses when soil test values show low amounts of available inorganic nitrogen.

Species	Rate		Species	Rate	
	Moderate soil test	Low soil test		Moderate soil test	Low soil test
	lb N per acre per growing month			lb N per acre per growing month	
Bermudagrass, Common	218	436	Fescue, tall	174	436
Bermudagrass, Improved	305	566	Grama, blue	44	131
Bluegrass, Rough	174	436	Ryegrass, Perennial	174	436
Buffalograss	44	174	Wheatgrass, tall	131	545

Phosphorus

The routine soil test at NMSU extracts plant available phosphorus using a sodium bicarbonate solution. This extractant has been shown to correlate very well with what a plant can remove from the soil. Table 8 interprets the extractable phosphorus into relative concentrations from very low to very high and attempts to ascertain whether or not there will be a response to added fertilizer.

Table 8. Interpreting soil inorganic phosphorus levels.

$NaHCO_3$ - P classification	ppm	Chance of a Response to added P_2O_5	$NaHCO_3$ - P classification	ppm	Chance of a Response to added P_2O_5
Very Low	< 7	High	High	23 - 30	Not Likely
Low	8 - 14	High	Very High	>31	Not Likely
Medium	15 - 22	Moderate			

New Mexico soils that are low in organic matter are usually low in plant available phosphorus. The alkaline pH of western soils usually keeps phosphorus unavailable to plants and should be supplemented to a growing crop. As many as two applications per year may need to be made in order to keep a healthy and vigorous root system. Phosphorus fertilizers can be applied at 1/5th the nitrogen rate when making routine applications. The first fertilizer application in the spring, however, should contain the same rate of P (as P_2O_5) as nitrogen if the soil test indicates low levels of available nitrogen.

Potassium

NMSU is unique in its approach to soil potassium (potash = K_2O). A water extract is made of the soil and the amount of potassium in solution is determined. Most other labs commonly used by farmers and home owners rely on ammonium acetate as the extractant. Potassium levels should never be compared from lab to lab unless the methods are the same. Table 9 interprets the extractable potassium into relative concentrations from very low to very high and attempts to ascertain whether or not there will be a response to added potash fertilizer.

Table 9. Interpreting soil inorganic potassium levels.

Potassium - water extract classification	ppm	Chance of a Response to added K_2O	Potassium - water extract classification	ppm	Chance of a Response to added K_2O
Very Low	< 10	High	High	61 - 80	Not Likely
Low	11 - 30	High	Very High	>80	Not Likely
Medium	31 - 60	Moderate			

A sample reference chart

Table 10 depicts a cross reference chart used to estimate the N, P_2O_5, and K_2O needed for cotton based on soil testing for phosphorus and potassium. The nitrogen rate is based on low levels of available nitrogen.

Table 10. Estimated nitrogen, phosphorus, and potassium rates for cotton when soil nitrogen is low.

Phosphorus	Potassium Rating				
Rating	Very High	High	Medium	Low	Very Low
	Pounds N-P_2O_5-K_2O per acre				
Very High	120-0-0	120-0-0	120-0-60	120-0-90	120-0-120
High	120-0-0	120-0-0	120-0-60	120-0-90	120-0-120
Medium	120-40-0	120-40-0	120-40-60	120-40-90	120-40-120
Low	120-80-0	120-80-0	120-80-60	120-80-90	120-80-120
Very low	120-80-0	120-80-0	120-80-60	120-80-90	120-80-120

Micronutrients

Iron (Fe): Iron is extracted with DTPA (a chelate) by most western labs. Iron deficiencies can occur with sensitive plants grown in alkaline or calcareous soil. If the soil pH is above 7.5 there is less iron available to the plant because the chemistry of soil favors the formation of rock. Even though a soil may test high in available iron, lime-sensitive crops may still exhibit deficiency symptoms. Chelates are often used to keep iron in a more available form but care should be taken to choose EDDHA or DTPA as the chelate of choice in New Mexico over EDTA. Excessive watering can cause iron deficiency.

Table 11. Classification for DTPA extractable iron.

Parts per million (ppm) (DTPA extractable Fe)	Classification
< 2.5	Low
2.5 - 4.5	Medium
> 4.5	High

Zinc (Zn): Zinc, like iron, is extracted with DTPA (a chelate) by most western labs. Zinc can be an economic problem for many crops like corn and sorghum. Zinc is most unavailable in soils with a pH greater than 7.5. Extremely high levels of phosphorus can cause zinc deficiencies.

Table 12. Classification for DTPA extractable zinc.

Parts per million (ppm) (DTPA extractable Zn)	Classification
< 0.5	Low
0.5 - 1.0	Medium
> 1.0	High

Copper (Cu): Copper deficiencies have not been verified in New Mexico soils. Factors that contribute to copper deficiency are high organic matter, sandy textural class, and high pH.

Table 13. Classification for DTPA extractable copper.

Parts per million (ppm) (DTPA extractable Cu)	Classification
< 0.3	Low
0.3 - 1.0	Medium
> 1.0	High

Manganese (Mn): Manganese deficiencies have begun to show up in pecans and some other crops in New Mexico. Deficiency symptoms can occur under the same conditions that promote iron and zinc deficiencies.

Table 14. Classification for DTPA extractable manganese.

Parts per million (ppm) (DTPA extractable Mn)	Classification
< 1.0	Low
1.0 - 2.5	Medium
> 2.5	High

Soil Texture

The last item reported on an NMSU soil test is soil texture. Soils are composed of mineral particles with an infinite number of sizes and shapes. Individual mineral particles are divided into three major categories on the basis of their size - sand, silt, and clay (Table 15). Many of the important physical and chemical properties of soils are associated with the surface of these particles. NSMU estimates the soil texture by "feel" but sieves or hydrometer readings can be requested.

Table 15. Size limits of soil separates.

USDA		International	
Name of separate	Diameter (range)	Size Fraction ID	Diameter (range)
	mm		mm
Very coarse sand	2.0 - 1.0		
Coarse sand	1.0 - 0.5	I	2.0 - 0.2
Medium sand	0.5 - 0.25		
Fine sand	0.25 - 0.1	II	0.20 - 0.02
Very fine sand	0.1 - 0.05		
Silt	0.05 - 0.002	III	0.02 - 0.002
Clay	below 0.002	IV	below 0.002

The interpretation from soil texture should give an indication as to the water holding capacity of the soil and the maximum rate of irrigation (Table 16).

Table 16. Approximate amounts of available water held by different soil of different textures.

Soil Texture	Inches of water per foot of soil	Maximum Rate of Irrigation
	Inches	Inches per hour (bare soil)
Sand	0.5 - 0.7	0.75
Fine Sand	0.7 - 0.9	0.6
Loamy sand	0.7 - 1.1	0.5
Loamy fine sand	0.8 - 1.2	0.45

Table 16. Approximate amounts of available water held by different soil of different textures.

Soil Texture	Inches of water per foot of soil	Maximum Rate of Irrigation
Sandy loam	0.8 - 1.4	0.4
Loam	1.0 - 1.8	0.35
Silt loam	1.2 - 1.8	0.3
Clay loam	1.3 - 2.1	0.25
Silty clay	1.4 - 2.5	0.20
Clay	1.4 - 2.4	0.15

Conclusions

Soils are a complex biological, chemical, and physical system. Diligence in interpreting soil test results can save thousands of dollars in production costs. The only way to know what the soil is like is to start with a soil sample. NMSU SWAT lab can be reached at Box 30003, Dept 3Q, Las Cruces, NM 88003, phone 505-646-4422. Call for prices. Other labs can also be used (Table 17). Make sure they participate in a proficiency testing program.

Table 17. Soil testing laboratories that have or currently participate in the North American Proficiency Testing Program for Soil and Plant Laboratories.

Agricultural Testing and Research Lab
PO Drawer 1318
Farmington, NM 87499
505-326-2730

Servi-Tech Labs
PO Box 1397
1816 E. Wyatt Earp
Dodge City, KS 67801
316-227-7123
www.servi-techinc.com

MDS Harris
621 Rose St
PO Box 80837
Lincoln, NE 68501
402-476-2811
www.mdsharris.com

Soil and Water West, Inc.
1700 Southern Blvd.
Rio Rancho, NM 87124
505-891-9472

NMSU Soil, Water, and Plant Testing Lab
MSC 3Q, Box 30003
Dept of Agronomy and Horticulture
Las Cruces, NM 88003
505-646-4422

Ward Laboratories
4007 Cherry Ave
Kearney, NE 68848-0788
308-234-2418
1-800-887-7645
www.wardlab.com

Table 1. Selected hay testing laboratories certified by the National Forage Testing Association†, as of February 2001.

State	Lab Name/Contact	Address	Phone	certified method
Arizona	Chandler Analytical Laboratories Clark Misbet	POB 3280 Chandler, AZ 85224-3280	602/963-2495	chemistry
Colorado	Front Range Forage Testing Lab Kevin Romero	POB 495 Windsor, CO 80550	970/686-6475	NIRS
	Warren Analytical Lab Dr. Michael Aarsonson	POB G Greeley, CO 80632	970/356-6344	chemistry
	Weld Laboratories, Inc. Brian Wells	1527 First Avenue Greeley, CO 80631	970/353-8118	chemistry
Iowa	A&L Heartland Laboratories Lesa Nuzback	111 Linn St Atlantic, IA 50022	712/243-6933	chemistry
	Iowa Testing Labs, Inc. Mark Steinberg	POB 188 Eagle Grove, IA 50533	515/448-4741	NIRS/Chemistry
	Kent Feeds, Inc. Rich Craddick	1600 Oregon St. Muscatine, IA 52761	319/264-4394	NIRS/Chemistry
Kansas	Alfalfa Analytical Lab Shannon McCormick	POB 963 Lakin, KS 67860	316/355-6792	NIRS
	SDK Laboratories, Inc. Dennis H. Hogan	POB 886 Hutchinson, KS 67504	316/665-5661	NIRS/Chemistry
	Servi-Tech Laboratories Steve Harrold	1816 E. Wyatt Earp Blvd Dodge City, KS 67801	316/227-7123	chemistry
Mexico	Agro Lab Mexico, S.A. de C.V. Martin Traxler	705 Martens, PMB 12-105 Laredo, TX 78041	52-17-19-1247	chemistry
New York	Dairy One Forage Lab Paul Sirois	730 Warren Rd. Ithaca, NY 14850	607/257-1272	chemistry
Oklahoma	OSU Analytical Lab Michael Kress	048 Agricultural Hall Stillwater, OK 74078	405/744-7771	chemistry
Texas	Martindale Feed Mill Greg Shaw	POB 245 Valley View, TX 76274	940/726-5216	NIRS
Utah	Brigham Young University Bruce L. Webb	255 WIDB, BYU Provo, UT 84602	801/378-2147	chemistry
	Utah State Feed Analysis Lab Janice Kotuby-Amacher	USU Ag Science Logan, UT 84322-4830	435/797-2217	chemistry

† World Wide Web address: http://www.foragetesting.org/